

sp. n., and 1 *Nautilus*); and 15 Echinodermata (of Cidaridæ 10 new species and a fragment; of Galeritidæ 2 new species; of Cassidulidæ 2 new species; of Spatangidæ 2 species, 1 of them new; and one fragment of an Asterid).

To the 6 species of Mollusks already known from the freshwater group 5 species are now added, and all but one of them are figured together on plate xxvi.

Prof. E. D. Cope has compared the Vertebrate fossils from the Pernambuco basin with those of the Fox-hill group of the Western United States, and those of the Bahia freshwater group with the fossils of the Laramie group of the same region, these two being the upper members of the Cretaceous series of North America.

Mr. Derby mentions at p. 8 that, from about the latitude of Bahia northward to the coast near the city of Maranhã, the high interior plateau, against which the fossiliferous strata of the coast abut, is overlain by a thick series of sandstones and shales, which at several points have yielded many fish-remains, regarded as of Cretaceous age by Agassiz, but Jurassic by Newberry and Cope. Presumably older than the coast basins, and divided from them by an uprise of the land, should the plateau-beds prove to be of Cretaceous age, those on the coast will be referred to the middle or later part of that age.

The exact distribution of the marine fossils described by Dr. A. C. White is exhibited in an extensive and valuable table (with an explanation) by Mr. O. A. Derby at pages 264-271, "so as to facilitate the examination of the question as to whether the fauna of any of these localities (27 altogether) presents differences that indicate distinct geological horizons, or only such as might be expected from differences in geographical position, in the character of the rocks, and in the degree of completeness in which the fauna of each locality is represented in the collections."

The descriptions of the fossils (pp. 20-263) are enriched with Dr. White's wide experience of the varietal changes and migrational distribution of such organisms. The twenty-eight quarto lithographed plates give admirable representations of the specimens, whether perfect or otherwise, evidently with careful exactness; and with them and the elaborate descriptions we have a very valuable work of reference both for geologists interested in Brazil and for those who may be studying the Cretaceous formations in other parts of the world.

MISCELLANEOUS.

The Development of the Central Nervous System of the Pulmonata.
By Dr. FERD. SCHMIDT.

ALTHOUGH the development of the Gastropods, and of the Pulmonata in particular, has already often been the subject of close

investigation, the knowledge which we possess about it must still be termed incomplete. This is to a certain extent due to the fact that the majority of the treatises dealing with the question belong to a period at which the methods of investigation were not sufficiently developed, and when, moreover, many questions, the solution of which is to-day a matter of the first importance, were as yet entirely untouched. Recent writers have satisfactorily filled up a portion of these gaps in the development of the Gastropods, yet many a question—and this applies especially to the Pulmonata—still awaits its solution. I had the opportunity of collecting and examining a rich material of embryos of different terrestrial Pulmonates, and I purpose to give in the following pages a brief account of certain results of my investigations, which are not yet completely concluded, concerning the *development of the central nervous system*. An exhaustive account of the development of this, as well as of the remaining systems of organs, will, however, be reserved for a subsequent publication, in which my statements, supported by figures, shall be compared with those already to be found in the literature of the subject.

I investigated the development of the following forms:—*Succinea putris*, L., *Clausilia laminata*, Mont., and a few other species of the same genus; *Limax cinereo-niger* and *L. agrestis*, L. Excluding a few deviations, the forms mentioned agree well together in their development. The statements in the present paper refer to *Limax agrestis* and *Clausilia luminata*.

The entire central nervous system arises by proliferation of the external epithelium of the body, and is therefore exclusively ectodermal in origin, a fact which agrees with all reliable statements of recent investigators of Gastropod embryology. I preface my account of the origin of the several pairs of ganglia with a short description of the epithelium of an embryo at the corresponding stage of development.

The epithelium of the young and still spherical embryo consists, with the exception of four regions of the body which will be mentioned forthwith, of large cubical cells, the protoplasm of which is only very slightly stained by the reagents employed by me (alumcarmine and hæmatoxylin). On both sides of the wide oral opening, however, the epithelium is composed of close-packed cylindrical cells, which are considerably smaller and at the same time relatively elongate, and take a deep stain; these regions of the body therefore appear by condensed light as two oval, subsequently reniform, sharply circumscribed disks, the "*sensory plates*." Behind the oral region, corresponding to the subsequent ventral surface, there extends a roundish area, the cells of which are entirely similar to those of the sensory plates; this disk of cells soon projects as a blunt cone: it is *the earliest rudiment of the foot*. Bordering upon this, and extending on to the dorsal surface, we find a similar circular disk of cells—the *rudiment of the mantle, with the shell-gland*.

In the course of the further development the whole of the super-

ficial epithelium of the body, with the exception of the portion lying above the mouth—the subsequent “*cephalic vesicle*”—becomes transformed, owing to active multiplication of cells, into a tissue composed of little cylindrical elements.

The cerebral ganglia arise from the epithelium of the sensory plates in the form of solid proliferations, which separate from their matrix and soon become connected by a strong commissure lying above the fore-gut. Soon after this has taken place the sensory plates bud outwards on each side into three blunt papillæ, and so form *the earliest rudiments of what are subsequently the two tentacles and the oral lobes*. *The epithelium of the rudiments of the tentacles gives origin by proliferation to the tentacular ganglia*, while soon after the separation of the cerebral ganglia from the epithelium of the sensory plates the latter give rise to yet other structures, which subsequently come to have relations with the cerebral ganglia, and possess the highest interest for us. These structures are the “*cerebral tubes*.” I shall deal further with them below.

Simultaneously with the cerebral ganglia *the two pedal ganglia arise in a precisely similar way from the epithelium of the foot-plate*, and soon become connected together by commissures as well as by connectives with the corresponding cerebral ganglion of each side.

It is not until later that a third pair—the *visceral ganglia*—appear. *They arise by proliferation of epithelium in the neighbourhood of the orifice of the two primitive kidneys*, and after separating from the epithelium lie beneath the hind-gut; they become connected by commissures with each other and with the corresponding cerebral ganglion of each side. At this stage of development therefore the nervous system of the Pulmonata exhibits a surprising agreement with the typical disposition seen in many Lamellibranchs, e. g. *Unio* or *Cyclus*, while the central nervous system of the perfect snail (*Clausilia* or *Limax*) exhibits much more complicated and apparently quite different arrangements. How these are produced in the course of further development, how the separate parts become displaced from their relative positions, will be explained in my detailed work; in the present paper a short outline only is given. In the comparison of the embryonic with the fully developed nervous system of the Pulmonata, that which at once strikes us and at the same time renders more difficult the comparison of the latter with the nervous system of the Lamellibranchs, is the circumstance that the separate constituents of the central nervous system, the various ganglia, are much more complicated in structure in the adult snail, have apparently quite a different position with reference to one another, are partly fused together, or at any rate touch one another, and thus surround the foremost section of the intestinal tract as a single mass. They are therefore situated quite at the anterior end of the body, while in the embryo the several pairs of ganglia—corresponding to the primitive arrangement in the mussels—are quite distinct and imbedded in widely separated regions of the body. The following is probably the explanation of this apparent difficulty:—After the several pairs of ganglia have separated in the embryo from the epithelium of the surface of the body and have

become connected together by means of commissures they form an integral system of organs, the further development of which proceeds quite independently of the increase in size and, in different regions of the body in consequence of unequal growth, of the different expansion of the external contours of the body. In the embryo the visceral and pedal ganglia are relatively widely separated from the cerebral ganglia, with which they are united by relatively long commissures. All ganglia rapidly increase in size, while the commissures uniting them together do not increase in length in the corresponding ratio. It follows that a gradual approximation of the ganglia must result from this, until, as the ganglia continue to increase in volume, they finally come into contact with one another, while at the same time the various ganglia continually recede further from their place of origin, the surface of the body, which is rapidly extending in all directions.

We have already briefly alluded to the "cerebral tubes," structures which arise from the sensory plates after the formation of the rudiments of the cerebral ganglia, and which subsequently come into important relation with the central nervous system. They are developed in this way:—*Soon after the separation of the cerebral ganglia a sac-shaped invagination of the epithelium of the sensory plates takes place on each side below the ocular tentacle, and, growing continually deeper, finally comes into contact with the cerebral ganglion of the corresponding side*, though it still has for some time a communication with the exterior by means of a long canal. The duct of this "cerebral tube" subsequently closes, and loses its connexion with the external epithelium; the structure then lies, as a thick-walled vesicle, upon the cerebral ganglion. While the lumen of the vesicle gradually becomes narrower, and finally disappears entirely, an active multiplication of cells takes place in its walls, and at subsequent stages of development we find the primitive "cerebral tube" transformed into a roundish mass, which is completely fused with the corresponding cerebral ganglion; nevertheless the limits of the structure can still be determined with certainty, since its small constituent elements take a much deeper stain than those of the cerebral ganglia.

These structures, the "cerebral tubes," were discovered and their true importance recognized by Messrs. P. and F. Sarasin (*cf.* their "Entwicklungsgeschichte der *Helix Waltoni*, Reeve," in the 'Ergebnisse naturw. Forsch. auf Ceylon,' i. Bd. Heft 2, 1888).

In the tropical *Helix* examined by the above-mentioned authors two "cerebral tubes"—the structures were thus designated, and I have accepted the term—were found on each side, and in this respect therefore *Helix Waltoni* differs from *Clausilia* and *Limax*. As regards the *phylogenetic importance* of these peculiar organs, the view taken by Messrs. Sarasin appears perfectly justifiable:—*The cerebral tubes of the Gastropods correspond to the various organs described as cephalic pits, nuchal organs ("Nackenorgane"), &c. in many Annelids, and to the cephalic pits of the Nemertines.*—*Sitzungsberichte der Naturforscher-Gesellschaft bei der Universität Dorpat*, Bd. ix. Heft 2, 1891, pp. 277–282.